PH-AAA-020

ECONOMIC ASPECTS OF HIGH YIELDING VARIETIES OF RICE WITH SPECIAL REFERENCE TO NATIONAL PRICE POLICIES: IRRI REPORT *

Randolph Barker **

The new high yielding varieties of rice are spreading rapidly throughout tropical Asia. The introduction of these varieties has resulted in a whole new range of problems, not only at the farm level but in marketing and policy as well. This report gives special emphasis to current problems in national pricing policy.

The report is divided into four sections. The first section describes the historical development of the new varieties. Section 2 examines the experience with new varieties among a group of Philippine farmers. Section 3 documents the dissemination of the new varieties throughout the tropics based upon the limited evidence available. The final section is concerned with the implication of the new varieties for national price policy. This section deals principally with rice price policy, but is also concerned with the pricing of inputs used in rice production.

DEVELOPMENT OF THE NEW HIGH YIELDING RICE VARIETIES

The story behind the development of the new high yielding rice varieties is sketched briefly. To trace the origin of these rice varieties, one must examine the history of breeding for high yield in rice.

---

* Paper prepared for the Thirteenth Session of the FAO Study Group on Rice, Manila, 20-27 March 1969.

** Agricultural Economist, International Rice Research Institute.

Historical Developments

Before the turn of the century, the Japanese had already undertaken research to identify the morphological characteristics of the rice plant associated with high yield (1). Important successes were achieved in transferring and adapting the high yielding japonica varieties to other temperate zone countries. A breeding program initiated in subtropical Taiwan shortly after the turn of the century resulted on the development of the ponlai varieties in the early 1920's. Japonica varieties also were grown in California. The crossing of japonicas with indicas by a farmer-breeder in the 1920's produced a series of varieties which became popular in the Southern United States. These varieties combined the high yielding characteristics of the japonicas with the grain type of the indicas.

What distinguished the varietal improvement work in the tropics from that in the temperate zone prior to the 1960's was the failure to identify and breed specifically for the plant type characteristics which would produce high yield potential in the indica varieties. Traditional indica varieties of the tropics are tall, weak stemmed, leafy, heavy tillering, and photo-period sensitive. These characteristics are desirable for plant survival in a tropical environment when weed and water control are poor and cultivation practices are often primitive (13, 14). However, application of even small amounts of fertilizer to these varieties encourages lodging and the reduction of yield. Experience in Japan and elsewhere has demonstrated that fertilizer responsiveness and high grain yield potential were associated with very different characteristics - short stature, stiff straw, and erect leaves.

Prior to the establishment of the International Rice Research Institute, progress had been made in the varietal improvement programs in several tropical countries. The outstanding varieties of the tropics incorporated some of the desirable plant type characteristics. These improved varieties included H-4 from Ceylon, ADT-27 from India, BPI-76 from the Philippines, Mos. Peta, and Bengawan from Indonesia, Tangkai Rotan and Seraup 50 from Malaysia, and Dima from Surinam (15, p. 15).

Notwithstanding these achievements, the development of the semi-dwarf indicas in Taiwan was to have the most profound influence on subsequent rice breeding for high yield in the tropics. The origin of these dwarfs is not known, although the original variety was assumed to have come to Taiwan from the Mainland of China before the Japanese occupation. Dwarf mutants selected by farmers, perhaps decades ago, eventually entered the collection of the rice breeders in Taiwan. Even after the return of Taiwan to the Republic of China in 1945, attention continued to be centered on the improvement of the ponlai or japonica varieties. However, a program was initiated in 1949 at the Taichung District Agricultural Improvement Station to upgrade the indica varieties (4, 5). A cross using the semi-dwarf, Dee-geo-woo-gen, resulted in the development in 1957 of a new semi-dwarf indica, Taichung (Native) 1. Chandler (2) states that the importance of the Taiwan semi-dwarf varieties is comparable to that of the Japanese dwarf wheat, Norin No. 10, introduced into the United States after World War II.

Breeding for Plant Type

All of the above-noted achievements moved the tropics closer to a major yield breakthrough in rice production. The International Rice Research Institute as it began its operations in Los Baños in the Philippines in 1962, found itself on the threshold of this breakthrough. Many of the Institute's personnel had been involved in the years of rice improvement work in Japan, the United States, India, and Taiwan. In the words of M.S. Swaminathan, Director of the Indian Agricultural Research Institute, these scientists "spread all over the world the gospel of plant type in relation to yielding ability" (17, p. 3).

The initial breeding program of the Institute gave equal emphasis to two possible alternatives for achieving the desired plant type: (1) crossing japonica and indica varieties, and (2) crossing the semi-dwarf indicas developed in Taiwan and the United States with the tall indicas from the tropics. During 1962, 38 crosses were made, 11 of which involved the Taiwan semi-dwarfs Dee-geo-woo-gen and I-geo-tze as one of the parents. The majority of other crosses were made between the ponlai or Taiwan japonicas and the tall indicas.

Sterility as a result of the lack of genetic affinity in plant materials plus susceptibility to disease were problems encountered in the ponlai-indica crosses. The discovery that short stature in the Taiwan semi-dwarfs is controlled by a single recessive gene moved these varieties into a position of prominence in the breeding program (3).

The potential of a selection from one of these early indica crosses, IR8-288-3 (Dee-geo-woo-gen x Peta, now known as IR8) was first recognized in yield tests during the 1965 wet season. During the next year, this selection underwent intensive examination and testing by several of the departments at the Institute. The fertilizer trial data from the Agronomy Department is shown in Figures 1 and 2. Figure 1 compares the yield of six varieties at five levels of fertilizer at the Institute farm during the dry season of 1966. Figure 2 compares yields obtained for eight varieties using six levels of fertilizer at the Philippine government's Maligaya Rice Research and Training Center in Central Luzon. The selection IR5-47-2 (Tangkai Rotan x Peta, now known as IR5) also demonstrated its high yielding ability in this later trial.

The results in Figures 1 and 2 show two important relationships. First, with fertilizer added IR8 achieved its maximum yield with a range of approximately 1 to 2 tons above the improved indicas and 3 to 4 tons above the native indicas. Second, at zero fertilizer, IR8 did as well as somewhat better than most other varieties.

During the next few crop seasons, IR8 was tested in a wide range of yield trials throughout the tropical rice growing regions of the world. The gap between IR8 and local varieties differed from country to country depending on the degree of success already achieved in the local breeding program. Nevertheless, the consistent ability of IR8 to perform at or near the top in these yield trials under a wide range of climatic conditions throughout the tropics gave clear vindication of the early

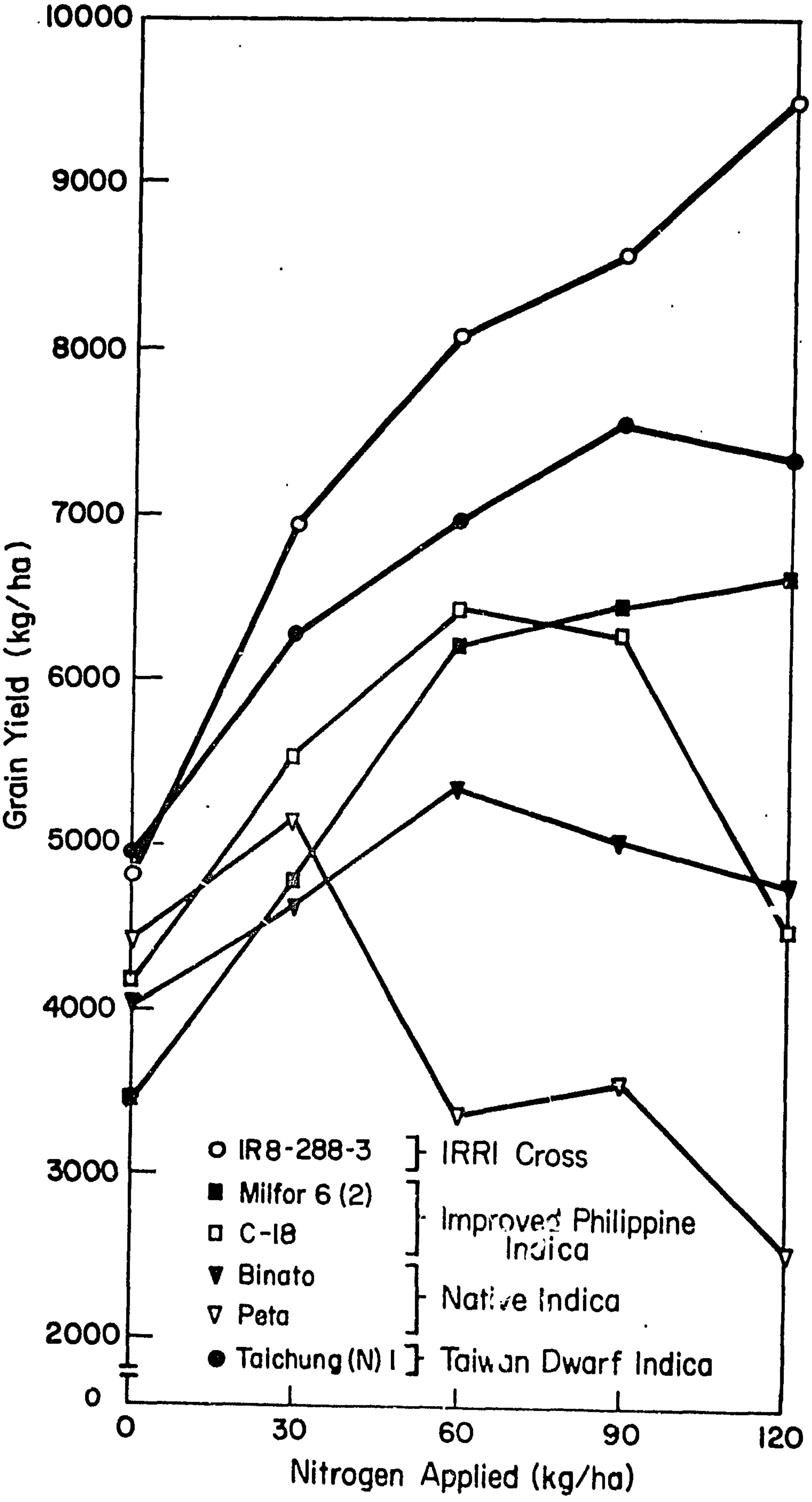


FIG. 1. Grain yield response of six rice varieties. IRRI, 1966 dry season.

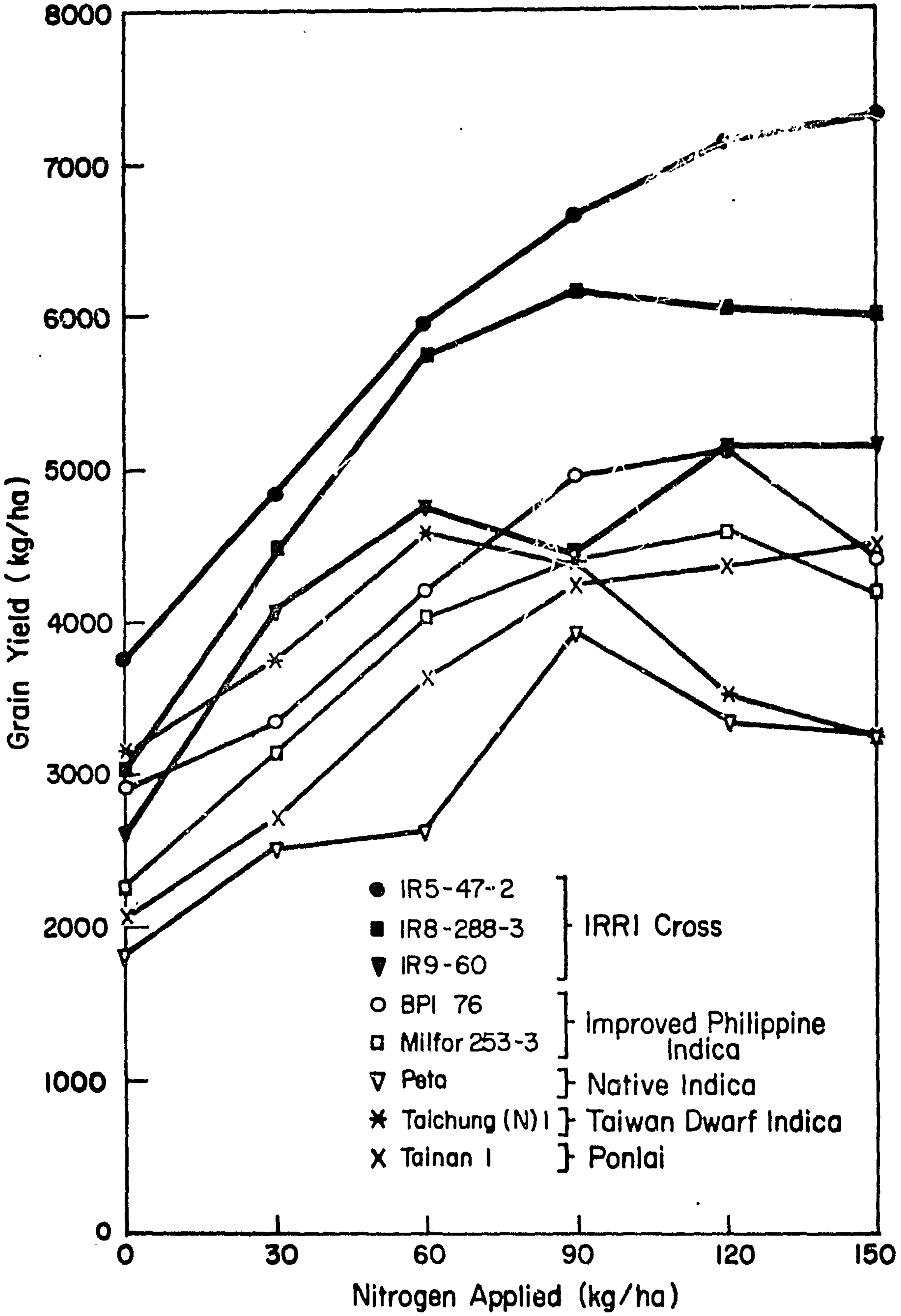


FIG. 2. Grain yield response of eight rice varieties. Maligaya Research and Training Center, Central Luzon, 1966 wet season.

decision to breed for plant type. This selection was officially recognized as a new variety on November 28, 1966, the first to be released by the Institute.

In the initial effort to establish a plant type with high-yielding ability, cooking and eating quality were deemphasized but not ignored. Earlier experience suggested that once the physiologically efficient plant type was developed, grain quality could be changed through further breeding to suit the various taste preferences without sacrificing yielding ability. Following the achievement of the plant type emphasis has shifted toward improvement of grain quality, and disease and insect resistance. Current progress in this direction suggests that varieties such as IR8 and IR5 will soon be replaced by others of superior grain quality.

Regardless of which of the new varieties become popular in the future, the new plant type which they represent will continue to be grown throughout the tropics. The reason for this can be seen by analyzing not only the biological response but also the economic performance of these varieties.

FARMER EXPERIENCE WITH THE NEW RICE VARIETIES IN THE PHILIPPINES

This section draws on information from recent farm surveys conducted in the Philippines to examine the farm level experience with new vs. local varieties with respect to: (1) the adoption pattern, (2) the level of resource use, and (3) returns and costs. The farm surveys are by no means representative of the Philippines, but have been conducted in what must be regarded as the more progressive rice growing areas. Nevertheless, the information obtained does bring to light a number of important factors of interest to both producers and policy makers.

The Adoption Pattern

A survey has been conducted annually on 155 Laguna farms during the past three years to observe the changes taking place with the new high yielding rice varieties. Although 90 percent of the farm operators are tenants, both the level of management and resource input is higher than would be found in many regions. Laguna Province has relatively good irrigation facilities, and provincial yields are normally well above the national average.

Information on the pattern of adoption of new varieties is presented in Table 1. Comparisons are made in this table between the yield performance of the new vs. local varieties. New varieties include here IR8, IR5, C4-63, and BPI-76. The new variety most commonly planted was IR8. During the wet season of 1968, for example, only 12 out of 127 adopters planted new varieties other than IR8.

The major shift to IR8 occurred in the wet season of 1967 which was the first time that the seed became available in large quantity. Official government statistics show that over 428 thousand hectares or 13 percent of the riceland in the Philippines was planted to this variety during the 1967-68 crop year. For the survey farms in question,

TABLE 1. Adoption pattern for new varieties on 155 farms, Laguna, Philippines, 1966 to 1969.

	1966	1967		1968		1969
	Wet	Dry	Wet	Dry	Wet	Dry
Area planting new varieties (%)	1	8	55	53	75	67
Farms planting new varieties - total						
Farms planted (no.)	4	14	70	62	87	69
Farms irrigated (%)	100	95	83	88	90	93
Number full-adopters	1	9	60	62	83	63
Yield/hectare - full-adopters	4360	4710	4220	3480	3340	-
Farms planting new varieties - first time						
Farms planted (no.)	4	11	57	14	11	1
Farms irrigated (%)	100	92	80	45	67	50
Number of full-adopters	1	7	47	12	9	2
Yield/hectare - full-adopters	4360	4530	3300	2770	2820	-
Farms planting no new varieties						
Farms planted (no.)	96	86	30	38	13	31
Farms irrigated (%)	79	78	68	66	84	79
Number of non-adopters	149	134	47	56	19	43
Yield/hectare - wet season	2376	2420	2110	2990	2770	-
Total farms planting rice (no.)[a/]	155	155	155	147	146	138

[a/] Some non-irrigated farms have shifted out of production in certain seasons and nine farms were converted into housing sub-divisions in 1968.

146 of the 155 farms had planted IR8 in at least one season by the end of 1968. Seventy-five percent of the area and 87 percent of these farms were planted to new varieties in the 1968 wet season.

A seasonal pattern has begun to emerge. A larger number of farmers are planting new varieties in the wet as compared with the dry season. The reason for this shift is related to the price differentials previously mentioned. Local varieties will respond to medium input levels of nitrogen during the dry season without lodging. This strategy of choosing separate wet and dry season varieties seems particularly appropriate on those farms with uncertain or limited dry season water resources. Farm operators in this situation can ill-afford the risk associated with the high levels of fertilizer input needed to maximize profits for IR8 during the dry season.

Another interesting observation from Table 1 is that the yield of farms planting new varieties has decreased as the number of adopters has increased. Yields are presented only for those farms planting 100 percent of their land to new varieties, and can be compared with yields of those planting local varieties shown at the bottom of the table. As more and more farmers switched to new varieties, both the farm resources and the level of inputs of the later adopters were considerably lower. This fact can be clearly observed with respect to the most critical input, irrigation. Nearly 100 percent of the farms of early adopters (those planting new varieties for the first time in the wet season of 1966 or dry season of 1967) were fully irrigated. This level dropped to about 50 percent for the late adopters. Because of the uncertainties involved, poor irrigation facilities are associated with lower input levels, lower yields, and lower farm profits.

While the yield of the new varieties has shown a downward trend, the yield of local varieties has increased. To understand the reason for this, it is necessary to examine in more detail the changes taking place in varieties and resource use. During 1966 and 1967, farmers were planting two new and nine local varieties. Among the local varieties, Malagkit, a glutinous rice not consumed regularly in the household but used in specialty items, received a price approximately double that of IR8. Malagkit is not grown extensively throughout the Philippines, but only in a few local areas. By the wet season of 1968, the number of new varieties being grown had increased to four while the number of local varieties had declined to only two. However, of the 146 farms interviewed (9 of the original farms sampled had been transferred into housing subdivisions), all but four were growing either IR8 or Malagkit. The price for Malagkit, although lower than in 1967, was still high enough to accord the variety a higher level of management and care than has been customary with other local varieties. A comparison of input levels, costs and returns for IR8 and Malagkit is shown in Table 2 and will be discussed subsequently.

The Change in Resource Use

Many of those switching to new varieties for the first time adopted not just a new variety but a whole new package of inputs. This fact is illustrated in Figure 3, which shows the range of yields and input levels for IR8 and local varieties in the 1967 wet season. Yield distributions are shown in the upper left hand corner. Not only is the average yield higher, but the distribution suggests that the potential for high yields is greater and the risk of low yields less than with local varieties. This point cannot be overemphasized in explaining the rapid adoption of the new varieties.

For all three of the inputs shown, there is a positive correlation between level of input use and yield. The level of inputs was considerably higher for IR8 than for local varieties - three times as high on the average for fertilizer and insecticide, and more than 50 percent higher for labor. Farmers achieving yields in excess of 6 tons may have used levels of fertilizer which exceeded economic limits for the wet season.

The results presented in Figure 3 and duplicated in many other parts of Asia contradict the myths of conservative, non-responsive farmers and of lack of credit for profitable rural investments.

A Comparison of Returns and Costs

How profitable is it to grow new varieties? The best way to make the comparison between returns and costs for varieties is to measure the return above variable costs. Fixed costs such as irrigation fees, land taxes, and depreciation on equipment will be the same regardless of the variety grown. Variable costs include such items as

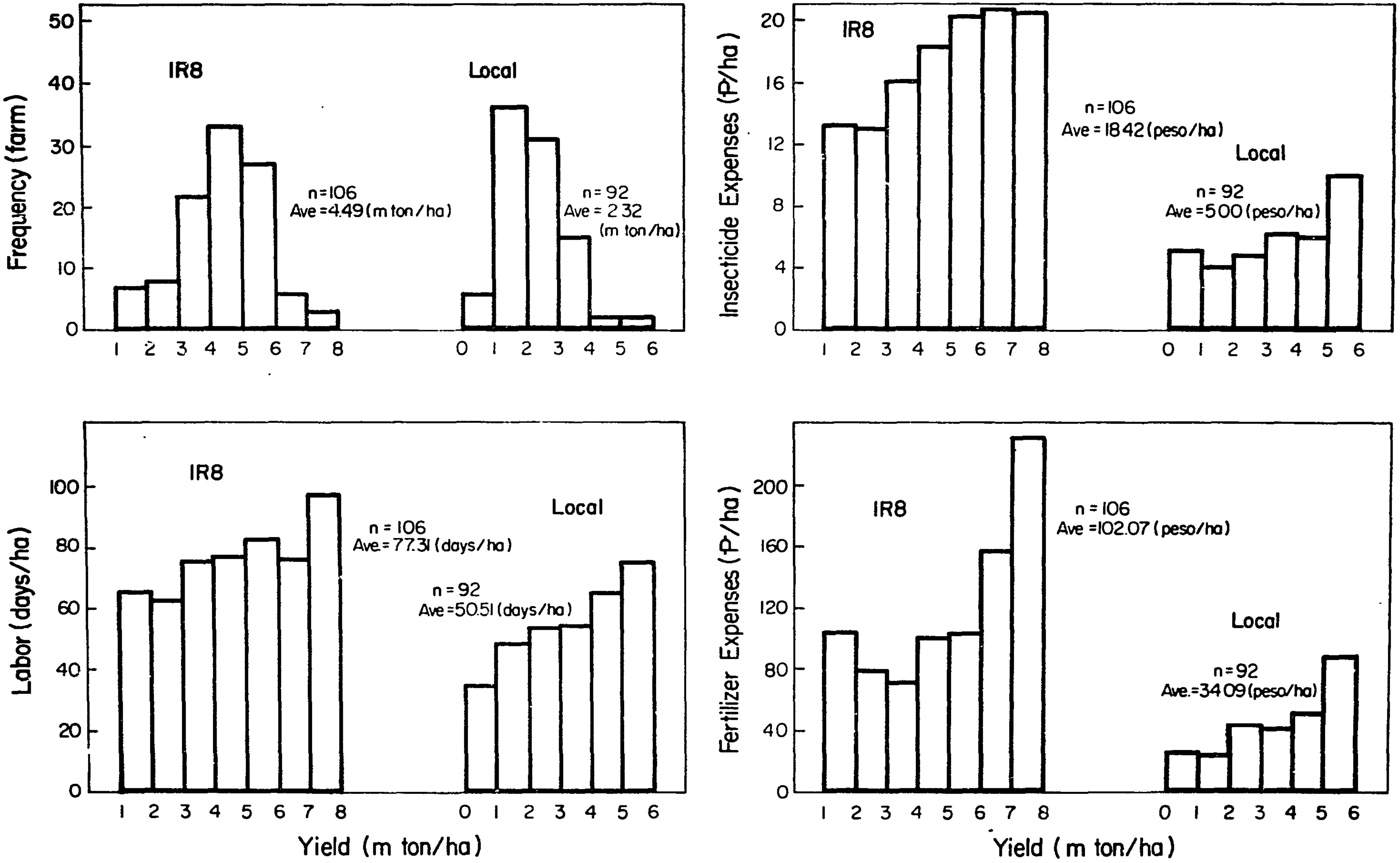


Fig. 3. Yield and input distribution of IR8 and local rice varieties. Laguna, wet season, 1966-67.

seed, fertilizer, chemicals, hired labor, and the harvester's share of crop yield. These costs will differ depending on the level of inputs used and the level of output attained.

Table 2 compares the returns and costs for IR8 and local varieties in the 1967 and the 1968 wet seasons. The level of inputs used and cash costs for these inputs are shown at the top of the table while the cost and return relationships are summarized at the bottom. IR8 is compared with all local varieties in 1967 and only with Malagkit in 1968.

Considering first the physical relationships, there was relatively little change in resources used for IR8 between the two years. The somewhat lower yields for IR8 may be due to the fact that later adopters appear to have somewhat poorer water resources. Also, the early adopters of IR8 with the superior resources had already begun to shift to other new varieties or to Malagkit. Only nine of the 23 early adopters were growing IR8 exclusively by the wet season of 1968.

As pointed out earlier, the concentration on Malagkit to the virtual exclusion of other local varieties resulted in an increase in input levels and yields. The most striking change was in the level of fertilizer use. In 1967, local varieties received an average of 20 kilograms of elemental nitrogen per hectare. The 15 Malagkit farms summarized in 1968 reported an average of 56 kilograms of nitrogen which was only 22 kilograms below the average being used on IR8. As a consequence of better management and higher input levels, yields were noticeably higher for Malagkit in 1968 than for local varieties in 1967.

TABLE 2. Comparison of returns and costs for selected varieties on farms in Laguna Province, Philippines, 1967 and 1968, wet season.

	Wet season - 1967		Wet season - 1968	
	IR8	Local a/	IR8	Malagkit b/
Number of farms	59	44	30	15
Physical inputs				
Farm area (ha)	2.4	2.4	2.4	1.6
Nitrogen (kg/ha)	75	20	78	56
Labor (man-days/ha) c/	76	50	69	58
Cash costs				
Fertilizer (P/ha)	99	30	92	63
Insecticide (P/ha)	19	5	24	11
Weedicide (P/ha)	8	9	10	7
Yield of rough rice in:				
Kg/ha	4310	2110	3700	2820
Cavans/ha	98	48	84	64
Price of rough rice				
P/kg	0.32	0.48	0.28	0.53
P/cavan	14	21	12.50	23.50
Gross return (P/ha)	1372	1008	1050	1504
Variable costs (P/ha) d/	406	295	475	458
Return above variable costs (P/ha)	966	713	575	1046

a/ Includes Malagkit, Binato, Intan, Wagwag, Surigao, Milagrosa, Raminad, Tjeremas, and Pilingbaybay.

b/ A glutinous rice used in specialty items.

c/ Pre-harvest only.

d/ Includes fertilizer, insecticides, hired labor, seeds, and harvester's share.

This reallocation of farm resources between years reduced appreciably the yield gap between local varieties and IR8. At the same time, the concentration on Malagkit tended to widen the price differentials even though the price of Malagkit declined from the previous year.

The effect on income of this resource shift is shown in the last line of Table 2. Inspite of lower prices for IR8 in 1967, returns above variable costs were still appreciably higher than for local varieties. However, by 1968 the higher price received more than offset the yield differentials between Malagkit and IR8.

Neighboring Rizal Province where Malagkit is not grown is also experiencing a change in varietal acceptance. Much of the shift can be attributed to the attempt of progressive farmers to obtain the high price for multiplied seed of new varieties (P30 to P35 vs. P13 to P17 per cavan of 44 kilograms). The initial emphasis on IR8 has now shifted toward C4-63, a new variety developed by the University of the Philippines College of Agriculture. The analysis of farm survey results indicate that C4-63 may offer the best combination of yield and price potential for the immediate future. However, there are three other selections, not yet named as varieties, now being tested throughout the Philippines. In the near future farmers should have a variety which gives top performance in the market place as well as in the field.

Conclusions from the Philippine Farm Experiences

Judging from the reports received from other countries, the experience of these Philippine farmers is not an isolated case (12). The early adopters, those farmers with better resources and management capabilities, have been in the best position to realize the yield and profit potential of these varieties. Later adopters with generally poorer water resources and lower level of cash inputs experienced lower yield increases.

Under the widely varying climatic conditions of tropical Asia, farm level success has not been uniform. For crops grown under irrigated conditions with high sunlight, the yield has been, in many cases, more than doubled. However, other farmers have found the new varieties unsuited to this particular climatic or cropping pattern, or not resistant to local diseases and insect attack.

An even more important threat to the initial enthusiasm with which the varieties were received is the prospect of lower rice prices. Prices have fallen in part because of the abundance of supply which in some regions has exceeded the capacities of drying, milling, and storage facilities. Of more direct concern to those planting new varieties has been the lower price received for certain of these varieties. For example, the most widespread of the new varieties, IR8, typically sells at a price 20 percent or more below local varieties in a number of Asian markets.

Farmers reflect their sensitivity to this price differential by switching back and forth between varieties looking for the combination of price and yield potential that will give the highest profits. As a consequence, progressive producers are still finding it profitable in many situations to plant local varieties. Continued efforts to improve grain quality and disease and insect resistance will make it possible in the near future to select from a wide range of high yielding varieties the one which best suits the particular farm situation. No one can say at this time which of the new varieties will become popular in a given area. However, recent experience in the Philippines suggests that IR8, the best known and most widely planted of the new varieties, may soon be replaced by others of superior grain quality.

THE DISSEMINATION OF NEW RICE VARIETIES THROUGHOUT THE TROPICS

The amount of land planted to the new varieties during the crop year 1968/69 may exceed 5 million hectares or 6 percent of the total riceland in South and Southeast Asia. The spread has been rapid but not uniform. The rate of diffusion differs among countries, among regions within a country, and among farms within a region. This section is concerned with acceptance of new varieties at the national level.

The starting point for the spread of new varieties is taken here as the crop season 1965/66 which marks the introduction into India of the semi-dwarf, Taichung (Native) 1. Varieties of medium to short stature with high yield potential introduced in the tropics after this date are categorized here as new. It is difficult to define precisely a new or high yielding rice variety. To date the principal new varieties in terms of planted hectarage are IR8 and IR5. A number of varieties recently developed through various country research programs, such as C4-63 and BPI-76 in the Philippines, are also included among the list of new varieties. ADT-27, which has been spreading rapidly in the Tanjore District of India, although developed several years ago, is included in the list. H-4 and H-8, which account for more than 50 percent of the rice grown in Ceylon, are omitted since their dissemination occurred well before 1965/66.

Where the Varieties are Being Grown

Until now the Philippines has been the major source of seed for the new varieties. Some of the seed was multiplied and distributed by the Institute as shown in Table 3. However, most of the estimated 6,500 tons of exported seed was produced by private growers and shipped through private or government channels. Table 4 shows the quantity of seed exported from the Philippines by year and, by country of destination.

Seed exports give a rough indication of where the new varieties are being grown and where the expansion is likely to take place in the immediate future. One ton of seed will plant 20 to 25 hectares, Allowing for a 50 percent loss in the production and distribution

TABLE 3. Seed of new varieties distributed by The International Rice Research Institute by country of destination, to Jan. 1, 1969 in metric tons. a/

Country	Year					
	1966	1967		1968		
	IR8	IR8	IR5	IR8	IR5	IR-253
	(metric tons)					
Burma	0.1			b/	b/	
Ceylon		0.5				
India		10.0				
Laos	0.1					1.0
Malaysia	3.0	3.0				
Nepal					b/	
Philippines	55.3	5.2	0.9	0.1	18.1	
Saudi Arabia				b/		
Vietnam (South)		b/	b/			
Total	58.5	18.7	0.9	0.1	18.1	1.0

a/ In 1965, 1 metric ton of Taichung (Native) 1 was sold to the Indian government.

b/ Less than 0.1 metric ton.

TABLE 4. Seed of new varieties exported from the Philippines by country of destination, to Jan. 1, 1969 in metric tons.

Country	Year					
	1967	1968 (6 months)				
	IR8	IR8	IR5	IR-253 b/	C4-63 b/	C4-113 b/
			(metric tons)			
Burma	200					
Ceylon		210				
Ecuador			a/			
Ghana					2	
Indonesia					1	
Iran		a/				
Israel	100	198				
Laos			2	2		
Liberia		1	1		1	
Pakistan	3,600					
Panama	10		a/			a/
Spain		12				
UAR	100					
Venezuela		10				
Vietnam (South)		1,807	205			
W. Germany		a/				
Total	4,010	2,238	208	2	4	

Source of basic data: Rice and Corn Administration, Philippine Government.

a/ Less than 1.0 metric ton.

b/ C4-63 and C4-113 are varieties developed at the University of the Philippines College of Agriculture, IR-253 is not an official IRRI variety, but a selection. It is a glutinous rice bred specifically to suit taste preference in the Upper Mekong River Basin.

channels, the expansion per crop season would be approximately 50-fold (1,000 hectares at the end of the first season, 50,000 hectares at the end of the second season). Thus, in two crop seasons, a relatively modest amount of seed can be multiplied into a quantity sufficient to meet local demand.

Table 5 shows the estimates of hectarage planted to new varieties by country and by crop year beginning in 1965/66. The table was compiled in cooperation with Dr. Dana G. Dalrymple, International Agricultural Development Service, U.S. Department of Agriculture. Most of these figures are either projections of government plans or predictions unsupported as yet by official government surveys. Making allowance for gross inaccuracies, the figures, nevertheless, are revealing. The most rapid dissemination has occurred in India, West Pakistan, and the Philippines. One of the major rice exporting countries, Thailand, does not appear in the table at all. The factors which have contributed to this varied rate of acceptance among countries are examined next.

Factors Influencing the Dissemination of New Varieties

The new varieties represent a potential for increased output per unit of input, and can thus be viewed as a technological improvement. The extent to which a technological change at the experiment station is transmitted to the farm is determined by a multitude of factors. These factors can be thought of as a series of potential obstacles, a certain number of which must be overcome at one time if

TABLE 5. Estimates and projections of hectarage of new rice varieties in Southeast and South Asia by country and year, December 1968. a/

Country and crop year	Total rice hectarage 1965/66 (1000)	Hectares new varieties (1000)	Percent 1965/66 riceland
Southeast Asia			
Burma	4,856		
1968/69		324	6.7
Indonesia	7,348		
1968/69		271	3.7
1969/70		809	11.0
Laos	648		
1967/68		1	c/
Malaysia	480		
1966/67		4.5	c/
1967/68		30	6.3
Philippines	3,109		
1966/67		75	2.4
1967/68		701b/	22.5
Vietnam, South	2,450		
1967/68		0.9	c/
1968/69		44	1.8
1969/70		200	8.7
South Asia			
Ceylon	492		
1968/69		10	2.0
India	35,274		
1965/66		6	c/
1966/67		887b/	2.5
1967/68		1,784b/	5.1
1968/69		3,440	9.8

(continued)

Table 5. (continued).

Country and crop year	Total hectarage 1965/66 (1000)	Hectares new varieties (1000)	Percent 1965/66 riceland
Pakistan, East	8,900		
1966/67		0.2	c/
1967/68		81	c/
1968/69		242	2.7
Pakistan, West	1,393		
1967/68		4	c/
1968/69		344	24.7
1969/70		405	29.1
Total	80,678e/		
1966/67		967	1.2
1967/68		2,602	3.2
1968/69d/		5,397	6.7

a/ Detailed description of data sources may be obtained through IRRI or through Dr. Dana Dalrymple, International Agricultural Development Service, U.S. Department of Agriculture. The definition of new in this table refers principally to varieties disseminated since 1965/66 and excludes H-4 and H-8 in Ceylon although hectarage of both varieties has been increasing.

b/ Based on official government survey.

c/ Less than 1 percent.

d/ Where data is not available, 1967/68 estimates is repeated.

e/ Includes all non-Communist countries in South and Southeast Asia.

the diffusion of technology is to occur. However, the initial expansion of production may create new problems which must be solved if sustained growth is to be achieved. For example, the existing marketing structure may be adequate for a small increase in production. However, a large and rapid expansion may overtax the system, both from the point of view of delivering the necessary inputs and processing the increased production. If continued technological progress can lead to a sustained increase in rice yield per hectare, it should eventually be possible to divert resources from the production of rice to other agricultural products. Irrespective of the rate of industrial expansion, existing rates of population growth preclude for most Asian countries the possibility of reducing the amount of labor on the land in the near future.

Factors influencing the rate and extent of acceptance of new varieties include: (1) water control, (2) degree of plant protection or resistance to insects, rodents, and disease, (3) availability of complementary inputs including seeds, fertilizer, chemicals, and credit for capital, (4) relative advantage of new over existing varieties, particularly in economic terms, (5) acceptability of the quality of the new grain, (6) the quality of the farm management, (7) the farm institutional structure, (8) the availability of adequate market resources including drying facilities, storage warehouses, and milling equipment, and (9) government institutional structure, incentive, and initiative.

It is impossible to single out any one of these series of complementary factors as most essential or critical. That the spread has been more rapid than initially anticipated by many observers seems to point to the advantage of the new plant type over existing indica varieties throughout a wide geographical area in the tropics. Another unusual feature relating to the initial acceptance has been the initiative and apparently successful promotional efforts undertaken by a number of governments which in the past have shown relatively little interest in agriculture.

It is too early to determine the extent of adoption that will occur in a given country, since the dissemination process has just begun. However, five of the nine factors listed above have been used as a basis for subjectively determining which countries appear to have more favorable, average, and less favorable conditions for adoption. The analysis is presented in Table 6. For a given country, each of the factors is identified in one of three categories from favorable to unfavorable. Those factors which appear particularly important in influencing the initial acceptance in a given country are underlined. Among the five factors, disease resistance and acceptability of grain quality can be overcome in a comparatively short time by further work in varietal improvement and are thus more temporary obstacles to expansion than, for example, poor water control.

The contrast between the more and less favorable situations can be seen by comparing West vs. East Pakistan. The very factors which

TABLE 6. Countries which appear to be in a more favorable or less favorable situation with respect to five factors influencing dissemination of new indica varieties in South and Southeast Asia, 1968. *a/*

	Factors				
	Water control	Availability of inputs	Yield advantage over existing varieties	Disease resistance	Quality acceptability of new rice grain
More favorable					
India	Average	Good	*High*	Average	Average
Malaysia	*Good*	Good	High	High	Poor
Philippines	Average	Good	*High*	Average	Average
West Pakistan	Good	Good	*High*	High	Average
Vietnam	Average	Average	*High*	Average	Average
Average					
Ceylon	Good	Good	Low	Average	Average
Indonesia	Average	Poor	Medium	Average	Average
Less favorable					
Burma	Poor	Poor	High	Average	Poor
East Pakistan	*Poor*	Average	High	*Low*	Average
Thailand	*Poor*	Average	Medium	Average	*Poor*

a/ Those factors thought to be particularly important in influencing the initial rapid or slow rate of adoption are underlined.

favor West Pakistan - high yield response due to the dry climate, water control, and a minimum of disease and insect problems - are major handicaps in East Pakistan. Much of East Pakistan's rice growing area floods with the annual monsoons. Disease and insect problems have made it virtually impossible to grow IR8 during the main crop season.

Implications of the Analysis

The introduction of new rice varieties will shift the comparative advantage in rice production throughout Asia. Water control will be a major factor influencing the rate and extent of adoption. The lowest-cost-producing areas are likely to be those which combine a relatively dry climate with adequate irrigation such as West Pakistan. If marketing facilities are adequate, these regions should become net exporters of rice. In view of this, the traditional Asian exporting countries, Burma and Thailand, may find increasing competition on the world rice market.

IMPLICATIONS OF THE NEW VARIETIES FOR NATIONAL PRICE POLICY

Traveling through Asia today, one is struck by the contrast in problems facing different regions. Technological advance has resulted in increased food grain production in some areas and has uncovered a host of what are now referred to as second generation problems. These second generation problems relate principally to marketing functions - drying, storage, milling, and export of rice, but include other political and social issues as well (9). In other areas, the so-called green revolution is making much less progress at the farm level, and there is still the concern about how to encourage farm production.

Against this background, a wide range of national policies are now being debated, many of which deal with the subsidization and/or taxation of rice and of the inputs used in rice production. To site a few specific examples, Indian policy makers are considering a proposal that would provide for: (1) a 0 percent tax on fertilizer, (2) a duty on electric pumps for irrigation, and (3) a higher tax on agricultural wealth or property (8). West Pakistan is currently debating the merits of a government-supported large scale mechanization program for agriculture (16). The Philippine government maintains a high support price on rice, but at present is criticized because it lacks the funds to purchase more than a token amount of rice at the support level (7).

It is not the purpose here to examine specific policies, but rather to study the general principles and factors to be considered in the pricing, primarily, of rice and also of the other inputs to be used in rice production. This section is divided into three parts which deal with: (1) the functioning of rice price in the economy, (2) the objectives of price policy, and (3) price policy and the new high yielding varieties.

The Function of Rice Price in the Economy

Because of the dominant position of rice in both production and consumption, rice price policy is of critical importance in the economies of most Asian countries. By contrast, one cannot point to a single agricultural commodity in the Western world that has so far reaching impact on the functioning of the national economy. It, therefore, seems appropriate to examine in more detail the effect of a change in rice price.

In an open economy, price influences the income levels of both producers and consumers, and serves to allocate resources in production. Consider how the impact of an increase in rice price is felt throughout the economy:

> Rice producers. For the rice producer, a higher rice price means more income and a greater incentive to grow rice. He may decide to increase hectarage of rice or production per hectare. The latter decision, as will be discussed subsequently, depends very much upon the nature of the response of rice production to increased inputs.
>
> Agricultural crops competing with rice. If farmers decide to shift hectarage or other inputs to rice production, or if lending institutions shift financial resources to the rice sector, production and income of competing crops will decline.
>
> Consumers. A higher rice price means a higher cost of living and thus a lower standard of living. If consumers must spend more of their income for rice, there will be less available for other goods. Many consumers may decide to eat less rice and more of other goods when the price rises.
>
> Businessmen. A higher rice price may force labor to demand higher wages. Higher wages mean a higher cost of production. A higher cost of production for export goods negatively influences the competitive position of these goods in the world market.

> The economy. Higher production of rice may mean a saving in foreign exchange for rice imports. It could also mean a loss in foreign exchange from other sources if the higher rice price leads to higher wages and higher prices for goods other than rice. This sequence of events would place inflationary pressure on the economy.

In short, a change in the price of rice benefits some segments of the economy.at the expense of others. In the case of rice, there is the constant danger that a price policy may lead to a serious misallocations of resources. The politician must balance the pros and cons in arriving at a policy that is equitable and in line with national objectives. A first step is to understand clearly the objectives sought by the price policy.

The Objectives of Price Policy

Four broad objectives of price policy are: (1) to increase production, (2) to stabilize prices, (3) to transfer profits or capital to support development of a sector, and (4) to transfer income to raise the living standard of a sector.

> Increasing production. For most of the countries in Asia today, a major policy objective is the achievement of self-sufficiency in the production of rice and certain other food grains. Self-sufficiency can be achieved by: (a) prohibiting imports, (b) transfering hectarage from other crops to rice, or (c) increasing rice yield per hectare. For some countries, there has been an additional alternative of opening up new lands. However, in most of South and Southeast Asia, this opportunity is now very limited. The first alternative would normally result in a very high and politically unacceptable rice price. The second alternative leads to the reduction in the output of competing crops which could reduce foreign exchange earnings or increase spending for agricultural imports. Thus, it is implicitly assumed by most people that rice self-sufficiency

means achieving adequate increases in production through a sustained increase in yield per hectare. This increased yield will not only eliminate the current deficit in production but also keep pace with a growing demand due mainly to population growth. A rice price support or a subsidization of inputs are the principal means considered for stimulating production per hectare. However, the absence of input responsive varieties of rice in the past resulted in a large number of price incentive programs which did not achieve the intended yield production response.

Stabilizing prices. The purpose of a stabilization policy is to reduce income fluctuations of both producers and consumers. For the producer, this will serve as a further incentive to production since it reduces uncertainty. Stabilization schemes involve the procurement and sale of stocks by the government which will reduce the price fluctuations at farm and retail level. The problem of determining an average size of stabilization stock and of developing the decision criteria for government procurement and sales which will maintain this average is more complicated than normally visualized. Deciding on the average stock level involves a trade-off of costs. First, there is the trade-off between the cost of maintaining stocks and the cost of price fluctuation. Second, there is the trade-off between the cost of maintaining stocks and the cost of obtaining improved forecasting data for both crop production and consumption. However, it seems certain in many countries that an improvement in crop production and consumption estimates is a necessary first requirement for a workable stabilization scheme.

Transfering capital. There is general agreement among economists that once a sustained growth rate is established in agriculture, farm profits must be taxed not only for further investment in agriculture (research, infrastructure development etc.) but also to promote industrial development. At the same time, price incentives may be necessary to sustain the agricultural growth rate. The potential conflict between these objectives can be minimized by skillful pricing and taxation policy. For the majority of Asian countries, for example, the level of fertilizer and other inputs used in rice production is extremely low. Every effort should be made to encourage the adoption of fertilizer responsive varieties and the use of inputs. At the same time,

> it is equally important to find a way to tax the rather substantial profits that can be achieved by some farmers. An income tax would be desirable but very difficult to administer. Cochrane (6, p. 39) has suggested in lieu of an income tax, a graduated land tax with tax rates per hectare increased according to the number of hectares operated. Such a tax would not discourage the use of inputs, but would tend to promote production efficiency. This tax would of course encounter strong opposition from politically powerful landlords in many countries.
>
> *Transfering income.* Many of the developed countries have used price supports as a means of transfering income to the agricultural sector. This is a welfare or equity measure designed to compensate the farm population because of the generally lower levels of income. Developing countries cannot afford these costly *parity* programs. At the same time, they cannot afford to overlook the equity issue. A number of policies currently being adopted are tending to widen the income distribution, leaving the well-to-do farm population relatively better off under the new program.

An examination of farm and retail rice price levels in several Asian countries indicates the wide difference in policy objectives among countries. Figure 4 and Table 7 provide information on rice prices at retail and at farm level for eight Asian countries in 1964-65. India and Indonesia have been omitted because of wide differences in prices in the different regions of these countries, and likewise Pakistan because of a major difference between East and West.

The traditional exporting countries, Burma and Thailand, have held farm prices below the world export price and are using the proceeds from the export of rice to finance government operations. Ceylon and Japan, both major importers, have a farm price support

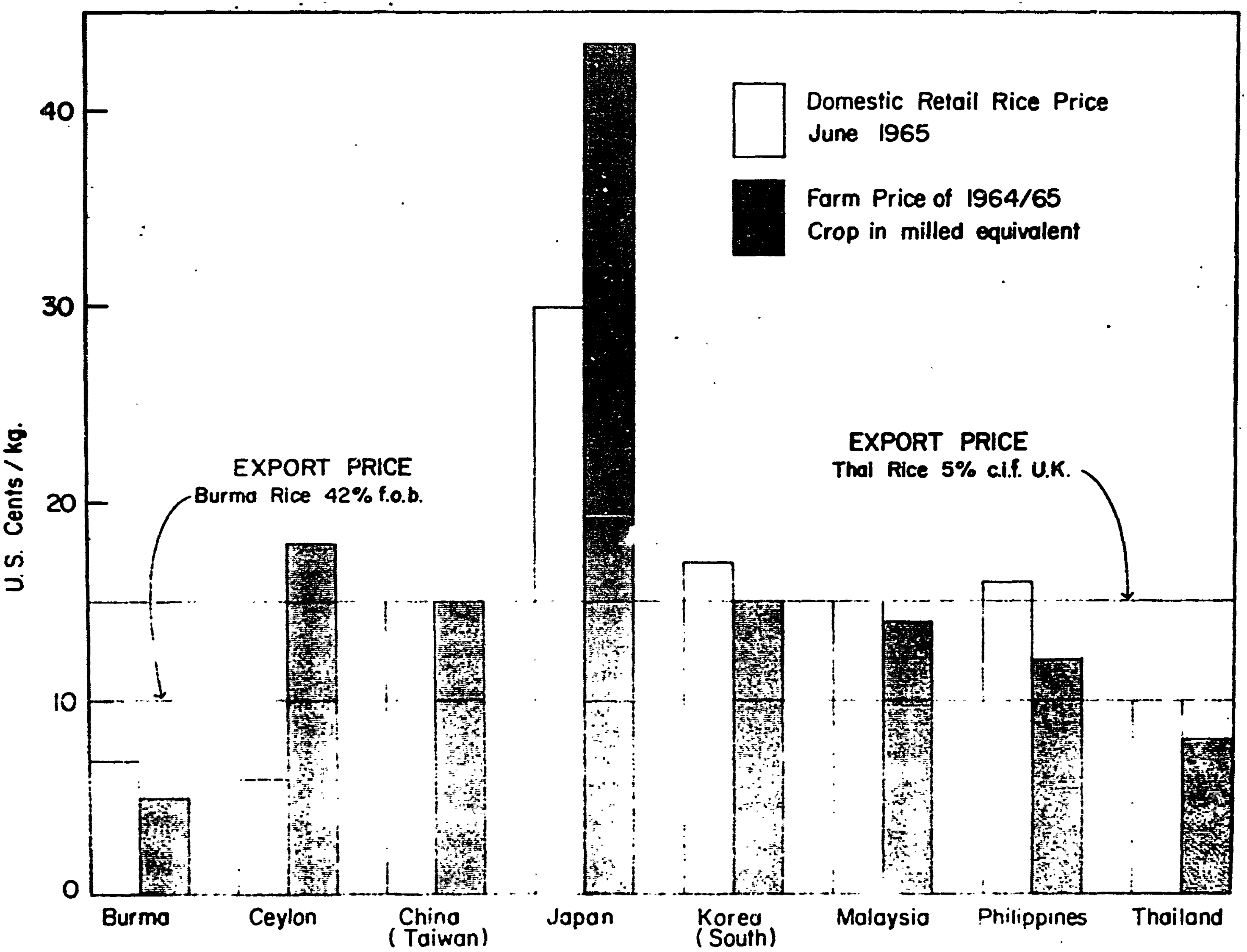


Fig. 4. Comparison of domestic retail and farm price of rice in eight Asian countries, 1964-65.

TABLE 7. Comparison of farm and retail rice prices and fertilizer price for eight Asian countries, 1964-65.

Country	Retail rice (US ¢/kg)	Farm rice		Nitrogen[b] (US ¢/kg)	Farm/retail (Col. 4 ÷ 2)	N/paddy (Col. 5 ÷ 3)
		Paddy (US ¢/kg)	Milled equivalent[a] (US ¢/kg)			
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Burma	7	3	5	29	71	9.7
Ceylon [c]	6	12	18	25	300	2.1
China (Taiwan)	15	10	15	44	100	4.4
Japan	30	28	43	26	143	0.9
Korea (South)	17	10	15	27	88	2.7
Malaysia	15	9	14	29	93	3.2
Philippines	16	8	12	36	75	4.5
Thailand	10	5	8	28	80	5.6

[a] Column 3 divided by 0.65 assuming as 65 percent milling recovery.

[b] Price of elemental nitrogen in the form of ammonium sulfate.

[c] The Ceylonese government has recently revised its program. It has stopped purchasing domestic rice but continues to import approximately 50 percent of total requirements which are given free to consumers.

Source of data: number refers to column number.

(2) FAO, State of Food and Agriculture, 1966.

(3) FAO, Production Yearbook, 1965 and FAO, National Rice Policies, 1966.

(4) FAO, Fertilizers, An Annual Review of World Production, Consumption, and Trade, 1965. Table XVIII. Data for crop year 1964/65 except Burma, 1960/61.

well above the retail price. The high farm prices have stimulated production, but the cost of such operations has resulted in a serious financial problem in both countries. Japan, the more highly developed country, can rationally view her policy as an equity measure. The purpose is not just to stimulate production but to transfer income to farm workers. The Ceylonese government has recently shifted to a somewhat less costly policy of distributing free to the consumers the 50 percent of the requirement normally imported and allowing domestic production to be sold on a free market.

Three of the four remaining countries - Korea, Malaysia, and the Philippines - do not appear to have adopted policies that are strongly beneficial or detrimental to either farmers, producers, or governments as of 1965. Domestic retail price in these countries is generally in line with the world price and exceeds the farm price by the approximate cost of moving the rice from the farm through the markets to the consumer.

The situation of Taiwan is unique and is best discussed in connection with the rice-fertilizer price ratio shown in Table 7. The government of the Republic of China maintains a monopoly on fertilizer and employs a fertilizer-rice barter ratio which places the price of fertilizer to the farmer more than 50 percent above the world market. In this manner, the government has been able to transfer income from the farm sector. This policy is effective for Taiwan but would greatly discourage fertilizer use in other less advanced countries.

Pricing Policy and the New High Yielding Varieties

Many countries will find it necessary to re-examine their rice price policy as a consequence of production gains and shifts in comparative advantage brought about by the new varieties. The price policy objectives will be influenced by the rate of growth in food grain output which may occur: (1) at or below the growth in demand for food grain, or (2) in excess of the growth in demand for food grain. The first situation, although ultimately less satisfactory from the point of view of potential growth in the economy, presents less problems for the policy maker. There is no danger of low food grain prices or unmanageable surpluses in the hands of government. The monolithic character of production, rice followed by rice, is not a major concern.

The second situation represents at once both a hope and a fear. The hope rests on the expectation that the pace of growth in food grain production will allow resources to be shifted to non-food grain crops. The fear is over the prospect that: (a) a rapid increase in food grain production in the face of an inelastic demand will drive food grain prices down, (b) the lack of flexibility will not allow a rapid shift to other cropping alternatives, and (c) the expanding population will face the prospect of growing underemployment or unemployment. In other words, there will not only be the lack of industrial alternatives to absorb the rural labor force, but a lack of non-food grain alternatives to absorb the food grain labor force. This is a grim prospect and indeed not one that faces most countries or regions in the immediate future. However, the prospect is real enough for some regions of Asia as to suggest a bold new direction for agricultural research.

The "beachhead" in varietal improvement for rice and other food grains has been established. The strength of the production response, as evidenced by the initial enthusiasm of Asian farmers, allays any fears that there will be a return to old varieties and old methods. As the new varieties spread, efforts are continuing in almost every country to improve the grain quality and disease and insect resistance of these varieties without loss of yield potential.

The time has now come to examine the requirements of a flexible agriculture, one which possesses alternatives to food grain production, and to direct research toward achieving this objective. The first and most obvious fact is that the kind of agriculture which can respond to price changes and can continue to absorb the growing labor force cannot be achieved by varietal improvement alone. The new research effort must include three other areas: (1) irrigation, (2) multiple cropping, and (3) marketing.

> Irrigation. More has been written about the need for improved irrigation than on almost any other subject. But one has the feeling that serious efforts to move irrigation development in the right direction have not yet been undertaken. Major emphasis is now directed toward the raising of capital to finance the construction of dams and the purchase of irrigation pumps. Yet, if this new investment in irrigation is to become truly productive, a great deal of research must be accomplished

first. For example, farmers in southern Taiwan responded to an increase in the Japanese price of bananas in the mid-1960's by planting bananas instead of rice in the paddy fields. By contrast, bananas cannot be grown on most irrigated farms in southern India because these farms lack drainage facilities. Irrigation problems encompass a broad spectrum from technical and engineering questions to social issues. The most pressing problems at the moment undoubtedly relate to the social matters dealing with the organization requirements for efficient operation of an irrigation system.

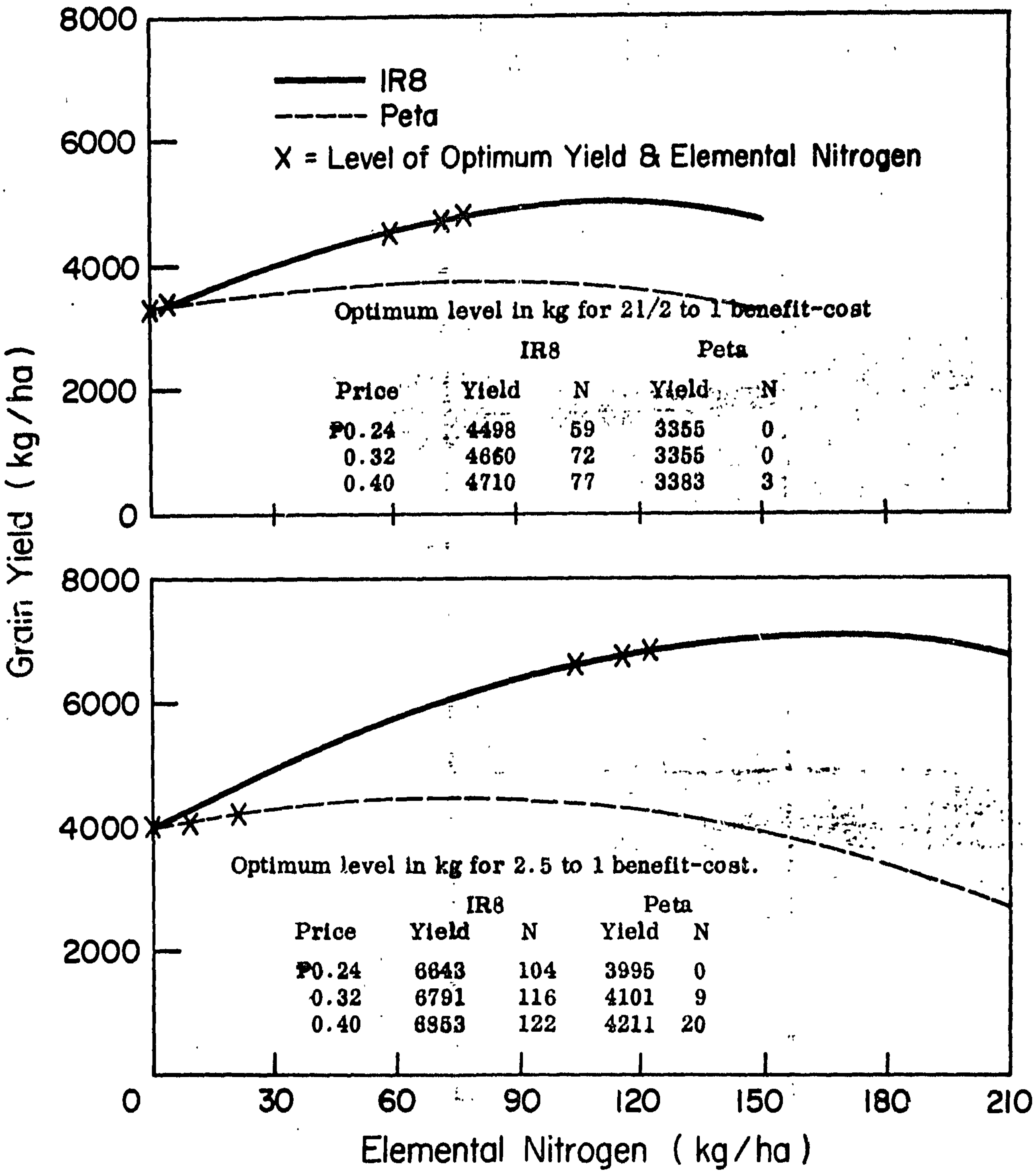
Multiple cropping. Adequate irrigation is a prerequisite for multiple cropping. It is the capacity for multiple cropping throughout the year which should ultimately give the tropics an advantage over the temperate zone in the production of food. The importance of research in multiple cropping is becoming more apparent with the decline of rice prices in many areas. Farmers will continue to produce rice even at very low prices unless the risks and uncertainties can be reduced for other cropping alternatives.

Marketing. The expansion of production in rice has resulted in a number of marketing problems. However, it should be emphasized that the rice market is one of the most highly developed markets in Asia. Unfortunately, in almost every crop with the exception of the food grains, efforts to improve crop productivity alone is not likely to result in major production gains at the farm level. In the case of soybeans for example, production acreage must be matched to processing plant capacity.

The resources required to carry on research and to fully develop the rural infrastructure and marketing sector must come to a large extent from the rural sector itself. As previously noted, this would require a selective policy of incentives and taxation. The introduction of new rice varieties creates the appropriate environment for both measures. However, timing is crucial particularly in the case of incentives, and these should be looked on to a large extent as temporary measures designed to encourage initial acceptance of the new technology.

This matter deserves further examination since it relates both to productivity and equity. Figures 5a and 5b show yield response curves in the wet and dry seasons, respectively, for an average of three years at the Philippine government's main experiment station in Central Luzon. The two varieties shown are the tall indica, Peta, and the new semi-dwarf indica, IR8. Allowing for a price discount due to uncertainty, the optimum levels of fertilizer input have been calculated for each variety under a wide range of rice price relationships. With traditional varieties of rice such as Peta, only small amounts of nitrogen application are profitable. For IR8, it is profitable to use a relatively high level of nitrogen input (higher of course in the dry than in the wet season when adequate irrigation is present). If the price of rough rice drops from ₱0.40 per kilo (US $100 per metric ton) to ₱0.24 per kilo (US $60 per metric ton) the optimum level of fertilizer input,shown by the crosses in Figure 2, changes relatively little. (The upper limit is the Philippine support price level while the lower limit is the price received by many Philippine farmers on the open market during the 1968 wet season main crop harvest). This implies that a farmer with adequate resources will continue to find it profitable to use substantial amounts of fertilizer with new varieties.

Most Asian farmers, however, have a very limited amount of capital or credit with which to buy fertilizer and other cash inputs. They cannot afford initially to apply even close to the recommended



Optimum level in kg for 21/2 to 1 benefit-cost

	IR8		Peta	
Price	Yield	N	Yield	N
₱0.24	4498	59	3355	0
0.32	4660	72	3355	0
0.40	4710	77	3383	3

Optimum level in kg for 2.5 to 1 benefit-cost.

	IR8		Peta	
Price	Yield	N	Yield	N
₱0.24	6643	104	3995	0
0.32	6791	116	4101	9
0.40	6853	122	4211	20

Fig. 5. a. Variability in optimum level of nitrogen and yield output level due to price effect. Maligaya, 1966, 1967 and 1968 wet seasons. Observations combined.

b. Variability in optimum level of nitrogen and yield output level due to price effect. Maligaya, 1966, 1967 and 1968 dry seasons. Observations combined.

levels and in many cases they are not familiar with the use of these inputs. When the fertilizer price rises or the rice price falls, these small farmers with few resources will have less income and, hence, less money available for the purchase of fertilizer. A lower rice price or a higher fertilizer price works particularly to the disadvantage of the small producer and will tend to widen the income distribution within agriculture.

Figure 5 also indicates, however, that the subsidy or price support to stimulate production should be temporary in nature. Once farmers have become accustomed to using fertilizer, they will continue to find it profitable to apply fertilizer to the highly responsive new varieties. The response functions for IR8 are comparable in magnitude to those for Taiwan rice varieties which were initially developed in the mid-1920's. Taiwan farmers have been accustomed to using a high level of fertilizer on rice for decades. As a consequence, the extremely unfavorable fertilizer-rice price ratio established by the government to tax the farm sector has not significantly reduced the level of fertilizer input.

The spread of the new varieties has increased interest in irrigation and mechanization as well as in the use of cash inputs. Here again, timing and selectivity are important. The adequately financed and well organized government irrigation schemes have been successful in Japan and Taiwan. However, in the majority of Asian countries, the unreliability of large government irrigation schemes has raised the question as to whether the emphasis should be placed upon the development of private tubewell systems. This expansion should undoubtedly be encouraged where possible since it raises the productivity of the labor as well as of the land. Other forms of mechanization have been questioned since they tend to be labor saving. There are peak periods of work during the cropping season, however, when labor is frequently in short supply. It may be desirable to mechanize certain operations to reduce the peak demand and to improve the timeliness of operations particularly where more than one crop is grown.

The introduction of new varieties has brought attention to two other areas related to pricing policy - production estimates and grade standards. The production forecast and estimation procedures worked reasonably well in a period when there was little change in the trend of rice output and year-to-year changes were due principally to weather. These procedures must now be revised and must take into account the increase in acreage planted to new varieties.

In rural areas of Asia, rice is not traded on any reliable set of quality or grade standards. The relatively poor quality of the early high yielding varieties (IR8, IR5, T (N) 1) has resulted in an increased awareness of quality. It is necessary to develop grade standards that can be applied not only at export level, but throughout the marketing channel. Farmers as well as merchants should receive a higher unit price for a higher quality product.

CONCLUDING REMARKS

The introduction of the new high yielding varieties has ushered in an era of change in rice production. Regardless of which of these varieties becomes popular in the future, the new plant type which they represent will continue to be grown throughout the tropics. The responsiveness of this plant type to fertilizer has given it an economic advantage over tall native indicas in many areas. This advantage will increase with further improvement in grain quality and in disease resistance.

The new varieties are spreading rapidly but not evenly throughout tropical Asia. There are many regions, particularly the rainfed areas, that have not benefited substantially from the new technology. In other areas, the increased production has been so rapid as to result in a number of problems relating particularly to the drying, storage, and marketing of rice. These events suggest the need for a change in research emphasis, not only to improve rice marketing, but also to create the environment for a more flexible agriculture, one in which there are profitable alternatives to rice production. The new areas of research emphasis should include irrigation, multiple cropping, and marketing.

The variable pattern of change in rice production requires a careful re-evaluation of national pricing policy. On the one hand, there is the need to encourage a sustained growth in production. On the other hand, there is the need to capture profits for the development of other sectors. Pricing policy must consider equity as well as productivity. Timing and selectivity are important in the choice of incentive or tax programs. A price support on rice or a subsidy on inputs such as fertilizer may encourage the adoption of the new technology, but should not be viewed as a long term program. Conversely, a tax on rice or cash inputs will discourage the use of new technology particularly among the smaller farmers, further widening the income disparity in agriculture. A more equitable arrangement would involve a tax on land rather than on the product or the cash inputs. Taxes or subsidies for irrigation and mechanization should be considered with a view to increasing the utilization of labor and labor productivity in the rural area.

Finally, the introduction of new varieties has called attention to the need for improved production estimates and grading standards. Without better production estimates, it would be difficult in many countries to effectively implement price support and price stabilization programs.

BIBLIOGRAPHY

(1) Baba, Isamu. Breeding of rice variety suitable for heavy manuring. Report presented to the Fifth Meeting of the International Rice Commission on Rice Breeding, Tokyo, October 1954, pp. 167-184.

(2) Chandler, Robert F. Jr. Dwarf rice variety is a giant in Asia. Manuscript prepared for the United States Department of Agriculture, Yearbook of Agriculture 1968, *Agriculture at Work for You Through Science* forthcoming.

(3) Chang, T.T. Analysis of short stature genes. Proceedings, Rice Technical Working Group, Little Rock, Arkansas, June 1966, pp. 18-19.

(4) Chinese-American Joint Commission on Rural Reconstruction. Rice improvement in Taiwan. Plant Industry, Series No. 15, Taipei, May 1959.

(5) Chinese-American Joint Commission on Rural Reconstruction. Crop and seed improvement in Taiwan, Republic of China, May 1959-January 1961, Taipei, July 1961.

(6) Cochrane, Willard W. Food and Agricultural Policy for India. Unpublished mimeo. The Ford Foundation, New Delhi, April 1968.

(7) Dalisay, Amado M. Economic Incentives for Increased Productivity. Editorial, *Economic Research Journal*, Vol. XV No. 1, June 1968.

(8) Dutt, Vishnu. Mr. Desai against the rest, a fertile controversy. *The Times of India*, Editorial page, New Delhi, March 5, 1969.

(9) Efferson, J. Norman. Observations on the current developments in rice marketing in West Pakistan. Discussion draft, Planning Cell, Agricultural Department, Government of West Pakistan, Lahore, January 1969.

(10) Food and Agriculture Organization of the United Nations. Incentives and disincentives for farmers in developing countries. Agricultural Planning Study No. 8, Rome, 1967.

(11) Food and Agriculture Organization of the United Nations. National Rice Policies. Rome, 1966.

(12) Hopper, W. David and Wayne H. Freeman. India's rice development moves from unsteady infancy to vigorous adolescence. Unpublished mimeo. Rockefeller Foundation, New Delhi, March 1969.

(13) Jackson, E.A. Tropical rice: the quest for high yield. Agricultural Science Review, Vol. 4, No. 4, Fourth quarter, 1966, pp. 21-26.

(14) Jennings, P.R. and L. Johnson. Breeding for improved rice production. Conference Report on Mechanization and the Worlds Rice, Coventry, England, September 1966, pp. 58-63.

(15) Jennings, P.R. Plant type as a rice breeding objective. Crop Science, Vol. IV, No. 1, January-February 1964, pp. 13-15.

(16) Kaneda, Hiromitsu. Economic implications of the "green revolution" and the strategy for agricultural development in West Pakistan. Pakistan Institute of Development Economics, Research Eeport 78, January 1969.

(17) Swaminathan, M.S. Rice Production: phenomenal increase possible. Indian Farming, Vol. XVII, No. 3, June 1967, pp. 3 and 52.